Magnetic Resonance Imaging in Basilar Artery Occlusion

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Context: Acute basilar artery occlusion has particularly high mortality and morbidity.

Objective: To determine the potential utility of advanced magnetic resonance imaging (MRI) methods, including diffusion-weighted imaging, for the early management of patients with basilar artery thrombosis.

Design: Case series.

Setting: Institute of Neuroradiology and Department of Neurology, Johann Wolfgang Goethe University, Frankfurt, Germany.

Patients: In 4 patients with occlusion of the basilar artery, MRI was performed, including T2-weighted and diffusion-weighted imaging (DWI) sequences and magnetic resonance angiography (MRA) in the short-term phase (<12 hours). Three patients underwent intra-arterial thrombolysis. Clinical outcome was obtained 10 days after symptom onset.

Results: The MRA was performed 3.5 to 11.5 hours after symptom onset and showed basilar artery occlusion in all cases. The DWI revealed different patterns of ischemic lesions. In 2 patients, no or only small lesions could be identified; the remaining showed multiple and large lesions within the posterior circulation territory. Initial clinical status was severely impaired in all cases (Rankin scale score, 4-5). Thrombolysis was initiated in 3 patients, leading to successful recanalization in 2. Clinical outcome was favorable in the 2 patients with small DWI lesions and successful reperfusion (Rankin scale score, 2), whereas it was worse in those with large DWI lesions and persisting occlusion (death, persisting coma).

Conclusions: In critically ill patients with acute basilar occlusion, the extent of DWI lesion involvement can be highly variable. Small DWI lesions seem to be associated with a favorable outcome if reperfusion is achieved with thrombolysis. This could potentially be the case independent of time from symptom onset.

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OCCLUSION of the basilar artery is a neurologic emergency that requires a rapid diagnostic evaluation and subsequent therapy. Intra-arterial thrombolysis may improve overall outcome in patients with basilar artery occlusion, but predicting benefit from therapy is still difficult in individual patients. This is probably partially owing to the fact that tissue injury in critical brainstem structures may already be irreversible in some patients before therapy is initiated. Angiographically, short occlusions, good collateral flow, and fast recanalization correlate with a favorable outcome. However, angiography does not show the extent of ischemic tissue injury directly.

Modern magnetic resonance imaging (MRI) methods, on the other hand, including diffusion-weighted imaging (DWI) and magnetic resonance angiography (MRA), are highly sensitive for the detection of ischemic tissue injury and may be suggestive of arterial occlusion, respectively. In the past, these methods have been applied mainly to anterior circulation stroke, with only a few case reports focusing on MRI (including DWI) in basilar artery occlusion. Currently, there are no established guidelines for selecting patients with suspected basilar occlusion for intra-arterial thrombolysis based on clinical or MRI criteria. Theoretically, the additional information provided by MRI methods could facilitate patient management and be predictive of therapeutic benefit.

Herein, we report a series of 4 patients with basilar artery occlusion, in whom MRI, including DWI and MRA, was...
PATIENTS AND METHODS

Between January 8 and July 27, 2000, 4 patients (2 men and 2 women; age range, 72-76 years) with acute basilar artery occlusion were included in the study. The clinical diagnosis and the Rankin score on admission and on follow-up 10 days later were established by a staff neurologist. In addition, MRI was performed in all patients on a 1.5-T unit (Siemens Vision; Siemens AG, Erlangen, Germany). Axial and coronal DWIs; axial T2-weighted; T2* (true transverse relaxation time)-weighted, and fluid-attenuated inversion recovery (FLAIR) images; and MRA were acquired using the following variables.

- T2-weighted turbo spin echo sequence: repetition time (TR), 2400 milliseconds; echo time (TE), 98 milliseconds; flip angle, 180°; field of view (FOV), 173 × 230 mm; matrix, 130 × 256; slices, 19; slice thickness, 6 mm; and acquisition time, 1 minute 8 seconds.
- FLAIR images: TR, 9000 milliseconds; TE, 110 milliseconds; flip angle, 180°; FOV, 201 × 230 mm; matrix, 132 × 256; slices, 19; slice thickness, 5 mm; and acquisition time, 1 minute 57 seconds.
- T2*-weighted gradient echo sequence: TR, 950 milliseconds; TE, 15 milliseconds; flip angle, 25°; FOV, 173 × 230 mm; matrix, 154 × 256; slices, 19; slice thickness, 6 mm; and acquisition time, 2 minutes 28 seconds.
- Echo planar imaging–DWI sequence: TR, 0.8 milliseconds; TE, 123 milliseconds; flip angle, 90°; FOV, 230 × 230 mm; matrix, 128 × 128; slices, 19; slice thickness, 6 mm; acquisition time, 5 seconds; and b=1000 with the diffusion gradient in one direction.
- 3-Dimensional time-of-flight MRA: TR, 35 milliseconds; TE, 6.6 milliseconds; flip angle, 20°; FOV, 142 × 190 mm; matrix, 200 × 512; slab thickness, 70 mm; number of partitions, 40; acquisition time, 3 minutes 45 seconds; and maximum intensity projection reconstruction.

In 3 patients, intra-arterial cerebral angiography and subsequent intra-arterial thrombolysis were performed using a microcatheter. The tip of the microcatheter was placed near or within the thrombus and a bolus of 200000 U of urokinase was administered. For up to 2 hours, the basilar artery was perfused with 500000 U/h of urokinase. In 1 patient, angioplasty of a basilar artery stenosis was performed following thrombolysis. The result of thrombolysis was documented by a selective control angiogram. In 1 patient, angiography and thrombolysis were not performed because of medical contraindications.

The site of basilar artery occlusion was classified according to Archer and Horenstein as caudal (from the confluence of the vertebral arteries to the anterior inferior cerebellar artery), middle (from the anterior inferior cerebellar artery to the superior cerebellar artery), and distal (distal to the superior cerebellar artery). The length of occlusion was termed short if only 1 part and long if 2 or more parts were involved. For follow-up imaging, either MRI or computed tomography was used.

### Clinical and Neuroradiologic Data of Patients*

<table>
<thead>
<tr>
<th>Age, y/Sex/ Delay Between Onset of Symptoms and MRI, h</th>
<th>Symptoms</th>
<th>Rankin Score on Admission</th>
<th>Rankin Score on Follow-up</th>
<th>Site of Occlusion of Basilar Artery</th>
<th>Thrombolysis</th>
<th>MRI on Admission and Follow-up</th>
</tr>
</thead>
<tbody>
<tr>
<td>72/M/2</td>
<td>Vertigo, anarthria, hemiparesis, palsy of cranial nerve III</td>
<td>4</td>
<td>2</td>
<td>Short, middle</td>
<td>Yes, recanalization</td>
<td>No initial lesion, PCA infarct on follow-up</td>
</tr>
<tr>
<td>75/F/5.5</td>
<td>Vertigo, anarthria, hemiparesis, diminished consciousness</td>
<td>5</td>
<td>2</td>
<td>Long, middle-distal</td>
<td>Yes, recanalization, PTA</td>
<td>DWI lesion in the brainstem, cerebellum; diminished on follow-up</td>
</tr>
<tr>
<td>76/M/3</td>
<td>Dysarthria, palsy of nerves IX and XI, deterioration of consciousness</td>
<td>4</td>
<td>Death</td>
<td>Long, caudal-distal</td>
<td>Yes, no recanalization</td>
<td>Large DWI lesion in the brainstem and cerebellum on initial MRI</td>
</tr>
<tr>
<td>74/F/11.5</td>
<td>Deep coma</td>
<td>5</td>
<td>5</td>
<td>Short, distal</td>
<td>No (coronary bypass surgery 3 days before)</td>
<td>Large DWI and T2 weighted imaging lesions in the brainstem, cerebellum, thalamus</td>
</tr>
</tbody>
</table>

*MRI indicates magnetic resonance imaging; PTA: percutaneous transluminal angioplasty; PCA, posterior cerebellar artery; and DWI, diffusion-weighted imaging.

performed in the short-term setting. We show the feasibility of MRI in these patients and report their outcome in relation to the initial MRI findings and subsequent treatment.

### RESULTS

All patients presented with focal neurologic signs compatible with posterior circulation ischemia and variable degrees of disturbed consciousness. The clinical features on admission and at follow-up, as well as the corresponding findings for MRI and MRA, are summarized in the Table.

Magnetic resonance imaging was performed between 2 and 11.5 hours after symptom onset. Acquisition of the 6 MRI sequences required about 12 minutes. In total, the MRI procedure required about 20 minutes, including transport, positioning of the patient in the scanner, and MIP reconstruction. In all patients, the MRI was diagnostic (despite reduced image quality in 2 patients because of movement).
Patient 1 was a 72-year-old hypertensive man who presented with vertigo, anarthria, mild left hemiparesis, and third nerve palsy. The MRI and DWI 2 hours after onset of symptoms revealed no structural lesion or diffusion deficit in the posterior circulation. A short, partially occluded midbasilar segment was visible on the MRA. Recanalization of the basilar artery was achieved with 800,000 U of intra-arterial urokinase. The control MRI showed an infarct in the posterior cerebellar artery territory on the right, probably due to clot fragmentation in the basilar artery and subsequent distal embolization, but no lesion in the brainstem or cerebellum was seen. The patient recovered and had a Rankin score of 2 ten days later.
Patient 2 was a 75-year-old woman who presented with vertigo, anarthria, severe right hemiparesis, third nerve palsy, and diminished level of consciousness. The MRI 5.5 hours after onset showed patchy lesions in the brainstem and cerebellum on DWI, which were partially also visible on T2-weighted images. A long occlusion of the middle and distal basilar artery was detected, which could be recanalized with intra-arterial thrombolysis (1000000 U of urokinase). A severe atherosclerotic stenosis of the midsegment was dilated with a balloon. In the control MRI, the DWI lesions diminished and only small infarcts were seen on T2-weighted images, which were smaller than the initial lesions on DWI. This patient also had a good recovery (Figure).

Patient 3 was 76 years old and had dysarthria, palsy of cranial nerves IX and XI, and diminished level of consciousness on admission that deteriorated rapidly. The MRI 3 hours after onset of symptoms revealed a total occlusion of the basilar artery with a large DWI lesion in the brainstem and both cerebellar hemispheres. Intra-arterial thrombolysis was not successful, and the patient died 10 days later.

Patient 4 was a 74-year-old woman who deteriorated rapidly 3 days after coronary bypass surgery and was in deep coma when she underwent MRI 11.5 hours after onset of symptoms. A distal occlusion of the basilar tip and large DWI lesions in the right thalamus, the territory of the posterior cerebellar artery, the brainstem, and the cerebellum were shown, which were partially already visible on T2-weighted images. This patient remained comatose.

In all patients who received both MRA and intra-arterial angiography, the site and length of occlusion were concordant on both imaging modalities.

**COMMENT**

Acute occlusion of the basilar artery is a neurologic emergency. The extent of the DWI lesion involvement can be highly variable, and the lesion volume does not significantly correlate with the National Institutes of Health Stroke Scale score. Several studies have suggested that intra-arterial thrombolytic therapy improves overall outcome in patients with basilar thrombosis. However, currently no criteria are available to decide who will likely benefit from thrombolysis and in which time window aggressive treatment should be initiated. Our results indicate that advanced MRI methods, including DWI, have the potential to become useful in this respect by revealing the extent of severe ischemic tissue injury in critical brain regions such as the brainstem.

Based on our small case series, we can draw some conclusions. First, patients with no or only relatively small DWI lesions have a potentially favorable outcome if reperfusion is achieved rapidly with intra-arterial thrombolysis. Most likely, the lack of a larger DWI lesion indicates tissue viability in critical structures. Second, small DWI lesions, even if located in the brainstem, do not exclude a favorable outcome. In one patient (patient 2) with successful reperfusion, the small, acute DWI brainstem lesion did not increase in size and the patient had a good recovery. In the same patient, another lesion located in the cerebellar peduncle appeared to slightly decrease in size on follow-up.

Currently, we cannot make firm conclusions on the significance of larger DWI lesions in acute basilar occlusion. Probably, larger DWI lesions, particularly if located in the brainstem, are predictive of poor outcome, both with and without treatment. However, the fact that DWI abnormalities may be potentially reversible must be considered, as recently shown by Kidwell et al.24 Probably, acute DWI lesions contain not only irreversibly injured tissue but also parts of the penumbra. Taken together, there is currently not enough data available to exclude patients with large brainstem lesions from thrombolysis.

Finally, from our experience, MRA seems to be highly accurate for predicting or excluding basilar artery occlusion. Bhadelia et al have shown that MRA has a good correlation with digital subtraction angiography in the detection and characterization of occlusive disease in the vertebrobasilar system. Possibly, subtotal stenosis may be occasionally mistaken for complete occlusion, but this does not have an impact on patient management, since both conditions would require emergency angiography. However, to properly analyze the accuracy of MRA, a substantially larger number of patients would have to be examined.

In summary, advanced MRI methods have the potential to become useful in the management of patients with possible basilar artery occlusion by (1) revealing or excluding basilar artery occlusion noninvasively and (2) showing the extent of severe ischemic tissue injury in critical brain structures.

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**Author contributions:** Study concept and design (Drs du Mesnil de Rochemont, Neumann-Haefelin, Berkefeld, and Lanfermann); acquisition of data (Drs du Mesnil de Rochemont, Neumann-Haefelin, Berkefeld, Sitzer, and Lanfermann); analysis and interpretation of data (Drs du Mesnil de Rochemont, Neumann-Haefelin, Sitzer, and Lanfermann); drafting of the manuscript (Drs Neumann-Haefelin and Berkefeld); critical revision of the manuscript for important intellectual content (Drs du Mesnil de Rochemont, Neumann-Haefelin, Berkefeld, Sitzer, and Lanfermann); study supervision (Drs du Mesnil de Rochemont and Lanfermann).

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**REFERENCES**


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